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BAKER BOTTS L.L.P.

30 ROCKEFELLER PLAZA

NEW YORK, NEW YORK 10112

TO ALL WHOM IT MAY CONCERN:

Be it known that WE, HANS-JOACHIM-FELKL, JOACHIM GÖEPEL, and ROBERT WINKLER, citizens of Germany, Germany, and Austria, respectively, whose post office addresses are Dreifaltigkeitsweg 8, D-91301 Forchheim, Germany; Fichtenstrasse 18, D-91094 Langensendelbach, Germany; and Donato-Polli-Strasse 54, D-91056 Erlangen, Germany, respectively, have invented an improvement in:

METHOD AND DEVICE FOR ROLLING A METAL STRIP
BY MEANS OF A SKIN-PASS ROLLING STAND

of which the following is a

SUBSTITUTE SPECIFICATION

FIELD OF THE INVENTION

[0001] The invention relates to an improved a method and a device for rolling a metal strip by means of a skin-pass rolling stand, wherein the thickness of the metal strip is reduced by the rolling in the skin-pass rolling stand.

BACKGROUND OF THE INVENTION

[0002] The rolling of steel by means of a skin-pass rolling stand serves primarily to roll specific properties into the steel by means of a slight reduction in thickness. The following are particularly suited for skin-pass rolling: flat products produced from soft steels for cold-working in accordance with DIN EN 10130 and DIN EN 10131; hot-rolled

metal strip in accordance with DIN EN 10051; precursor material for electrolytic strip surface treatment (DIN 17163-electrolytically galvanized, cold-rolled strip and sheet); relatively high-strength steels and phosphorus-alloyed steels with and without bake-hardening affects in accordance with SEW 093 and SEW 094; soft microalloyed steels in accordance with SEW 095; galvanized strip in accordance with DIN EN 10142; electric sheet produced from unalloyed and alloyed steels; non-grain-oriented, non-final-annealed steel in accordance with DIN 46400 Parts 2 and 4; and cold-rolled broad strip made from stainless, heat-resistant steels in accordance with DIN 59381 and 59382. The skin-pass rolling of soft steels (steel strips) for cold-working is carried out with the aim of eliminating the pronounced yield point of the steel strip, improving the planarity of the steel, strip and setting a defined roughness of the strip surface.

SUMMARY OF THE INVENTION

[0003] It is an object of the present invention to improve the quality parameters of steels or steel strips, such as for example the yield strength, the planarity, or the roughness of the steel strip, by means of skin-pass rolling. This object is achieved by a method and/or device for rolling a metal strip in a skin-pass rolling stand whereby the velocity of the metal strip when it enters the skin-pass rolling stand and the velocity of the metal strip when it exits the skin-pass rolling stand are set independently of the tension in the metal strip. In this way, it is possible to set the desired reduction in thickness with a high degree of accuracy, which results in a high quality metal or steel strip. The method according to the present invention is so accurate that it is even possible to reduce the yield strength in a steel in which a significant reduction of the yield strength

is only possible when the thickness is reduced by an amount which lies within a very narrow range, for example between about 0.475% and 0.525%. Accordingly, the invention is advantageously used for metal strips the thickness of which is reduced by between about 0.1% and 5%, and preferably between about 0.1% and 1%.

[0004] In a preferred embodiment of the invention, the velocity of the metal strip when it enters the skin-pass rolling stand and the velocity of the metal strip when it exits the skin-pass rolling stand are set in accordance with the ratio of the desired thickness of the metal strip when it exits the skin-pass rolling stand to the thickness of the metal strip when it enters the skin-pass rolling stand. Since the reduction in thickness is usually given as the lengthening of the metal strip or the elongation ratio, the velocity of the metal strip when it enters the skin-pass rolling stand and the velocity of the metal strip when it exits the skin-pass rolling stand are set by the ratio of the length of the metal strip when it enters the skin-pass rolling stand to the desired length of the metal strip when it exits the skin-pass rolling stand.

[0005] In a further preferred embodiment of the present invention, a means is provided for setting the velocity of the metal strip when it enters the skin-pass rolling stand, and a means is provided for setting the velocity of the metal strip when it exits the skin-pass rolling stand. Controllers are also preferably provided for controlling the means for setting the strip entry velocity and strip exit velocity. A set value for the velocity of the metal strip when it enters the skin-pass rolling stand is fed to the controller of the means for setting the strip entry velocity and a set value for the velocity of the metal strip when it exits the skin-pass rolling stand is fed to the controller of the means

for setting the strip exit velocity. The set value for the velocity of the metal strip when it enters the skin-pass rolling stand and the set value for the velocity of the metal strip when it exits the skin-pass rolling stand are set as a ratio of the desired thickness of the metal strip when it exits the skin-pass rolling stand to the thickness of the metal strip when it enters the skin-pass rolling stand. The same effect is achieved by setting the set value for the velocity of the metal strip when it enters the skin-pass rolling stand and the set value for the velocity of the metal strip when it exits the skin-pass rolling stand as a ratio of the length of the metal strip when it enters the skin-pass rolling stand to the desired length of the metal strip when it exits the skin-pass rolling stand.

[0006] In another preferred embodiment of the present invention, the set value for the velocity of the metal strip when it enters the skin-pass rolling stand is corrected as a function of a measured value for the velocity of the metal strip when it enters the skin-pass rolling stand and of a measured value for the velocity of the metal strip when it exits the skin-pass rolling stand.

[0007] In yet a further preferred embodiment of the present invention, the set value for the velocity of the metal strip when it enters the skin-pass rolling stand is corrected as a function of a temporal mean of measured values for the velocity of the metal strip when it enters the skin-pass rolling stand and of a temporal mean of measured values for the velocity of the metal strip when it exits the skin-pass rolling stand.

[0008] In yet another preferred embodiment of the present invention, the roll nip in the skin-pass rolling stand is set as a function of the tension in the metal strip upstream

of the skin-pass rolling stand and as a function of the tension in the metal strip downstream of the skin-pass rolling stand.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Further details of the present invention are described hereinbelow in connection with the drawings, in which:

FIGURE 1 illustrates a known control arrangement for a skin-pass rolling stand;

FIGURE 2 illustrates an exemplary embodiment of an improved control arrangement for a skin-pass rolling stand; and

FIGURE 3 illustrates a preferred embodiment of the improved control arrangement for a skin-pass rolling stand.

DETAILED DESCRIPTION OF THE INVENTION

[0010] FIGURE 1 shows a control arrangement for a skin-pass rolling stand 7 for the skin-pass rolling of a metal strip 1. The skin-pass rolling stand 7 has two working rollers 10 and 11 and two support rollers 8 and 9. The metal strip 1 passes through the skin-pass rolling stand 7 in the direction indicated by arrow 6. A means for setting the strip entry velocity, indicated by the rolls 2 and 3, is provided upstream of the skin-pass rolling stand 7. A means for setting the strip exit velocity, indicated by the rolls 4 and 5, is provided downstream of the skin-pass rolling stand 7. In FIGURE 1, the means for setting the strip entry velocity and the means for setting the strip exit velocity are designed as a bridle. However, they may also be designed as levelers, S-rolls or coilers. A velocity v_i is imposed on the metal strip 1 upstream of the skin-pass rolling stand 7 by means of the rolls 2 and 3. A velocity v_o is imposed on the metal strip 1 downstream of

the skin-pass rolling stand 7 by means of the rolls 4 and 5. To set the velocity v_o of the metal strip 1 downstream of the skin-pass rolling stand 7, a controller 21 is provided, to which a set value v* is fed. The controller 21 controls the rolls 4 and 5 in such a manner that the velocity v_o of the metal strip 1 when it exits the skin-pass rolling stand 7 corresponds to a desired set velocity v*.

[0011] Tension-measuring rolls 12 and 13, which measure the tension τ_i of the metal strip 1 upstream of the skin-pass rolling stand 7 and the tension τ_o in the metal strip 1 downstream of the skin-pass rolling stand 7, are provided upstream and downstream of the skin-pass rolling stand 7. The values τ_i and τ_o, together with their corresponding predetermined set values τ_i^* and τ_o^* and also a set value v_w for the velocity v_w of the skin-pass rolling stand 7, are input variables for a tension controller 14. The tension controller 14 controls the velocity v_w of the skin-pass rolling stand 7. In addition, the tension controller 14 emits a tension-dependent correction value k_τ.

[0012] In an exemplary embodiment of the invention, the tension-measuring rolls 12 and 13 have incremental sensors (not shown), which measure the rotation of the tension-measuring rolls 12 and 13. These measured values are used to form a strip-lengthening value e, to which the following relationship applies:

$$e = \frac{v_{o,m} - v_{i,m}}{v_{i,m}},$$

where $v_{o,m}$ is the velocity of the metal strip 1 downstream of the skin-pass rolling stand 7 measured by the incremental sensor of the tension-measuring roll 13, and $v_{i,m}$ is the velocity of the metal strip 1 upstream of the skin-pass rolling stand 7 measured by means

of the incremental sensor of the tension-measuring roll 12. A value v*(1-e), which has previously been added to the tension correction value k_τ, is fed to the controller 20 as set value for the velocity.

[0013] FIGURE 1 further illustrates that the rolling force in the skin-pass rolling stand 7 may be set to a predetermined set value $F\dot{w}$ by means of a controller 15. For the sake of simplicity, the feedback means for the controllers 15, 20 and 21 are not illustrated.

[0014] FIGURE 2 shows an exemplary embodiment of the invention, in which the velocity v_i of the metal strip 1 when it enters the skin-pass rolling stand 7 is set independently of the tension in the metal strip 1. In a preferred embodiment of the invention, the velocity v_i of the metal strip 1 when it enters the skin-pass rolling stand 7 is set to a set value v*(1-E*). In this case, E* is the set value for the elongation e of metal strip 1. Instead of the tension controller 14 as shown in FIGURE 1, a tension-monitoring means 22 is provided. The tension-monitoring means – which is advantageously designed as a tension controller with preceding dead band – emits an additional set value dF_w for the rolling force, instead of a tension-specific correction value k_τ, when the strip tension reaches the limit of its regulating range. The rolling force in this case remains as constant as possible.

[0015] FIGURE 3 shows a preferred exemplary embodiment of the invention which has been supplemented with a thickness-correction controller 25. The thickness-correction controller 25 determines a correction value k_E which is fed to the controller 20 and by means of which, for example, the set value v*(1-E*) is corrected.

[0016] The thickness controller 25 determines the correction value k_E in such a manner that the temporal mean ç of the strip-elongation value e corresponds to one of the set values of the thickness reduction E*. The temporal mean ç of the strip-elongation value e is formed by means of the functional block 26 in accordance with

$$\bar{e} = \frac{\bar{v}_{o,m} - \bar{v}_{i,m}}{\bar{v}_{i,m}}$$

where $\bar{v}_{o,m}$ is the temporal mean of the value $v_{o,m}$, i.e. the temporal mean of the velocity of the metal strip 1 downstream of the skin-pass rolling stand 7 measured by the incremental sensor of the tension-measuring roll 13, and $\bar{v}_{i,m}$ is the temporal mean of the value $v_{i,m}$, i.e. the temporal mean of the velocity of the metal strip 1 upstream of the skin-pass rolling stand 7 measured by the incremental sensor of the tension-measuring roll 13. The devices for forming mean values 27 and 28 are provided for the purpose of forming $\bar{v}_{o,m}$ and $\bar{v}_{i,m}$.